



Status Report (Q2-Q3 FY17) and Proposal (FY18)

Fast and lightweight

EIC integrated tracking system

Barrel MicroMegas (MM)

&

Forward Triple - Gas Electron Multiplier (GEM)

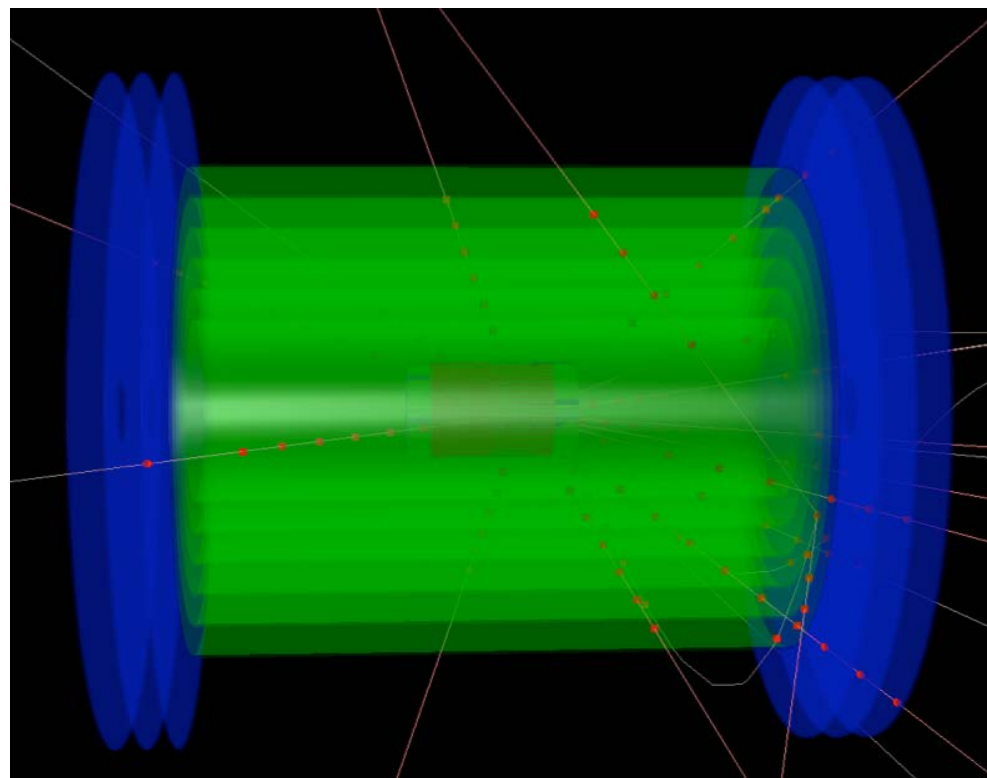
Franck Sabatie (PI),  
Maxence Vandenbroucke

Matt Posik,  
Bernd Surrow (PI)



# Outline

- Introduction
- **Generic R&D** program: Status
  - ☆ (1) Forward GEM tracking
  - ☆ (2) Barrel MM tracking
- **Generic R&D** program: Plans
  - ☆ (1) Forward GEM tracking
  - ☆ (2) Barrel MM tracking
- Budget request FY18
- Summary



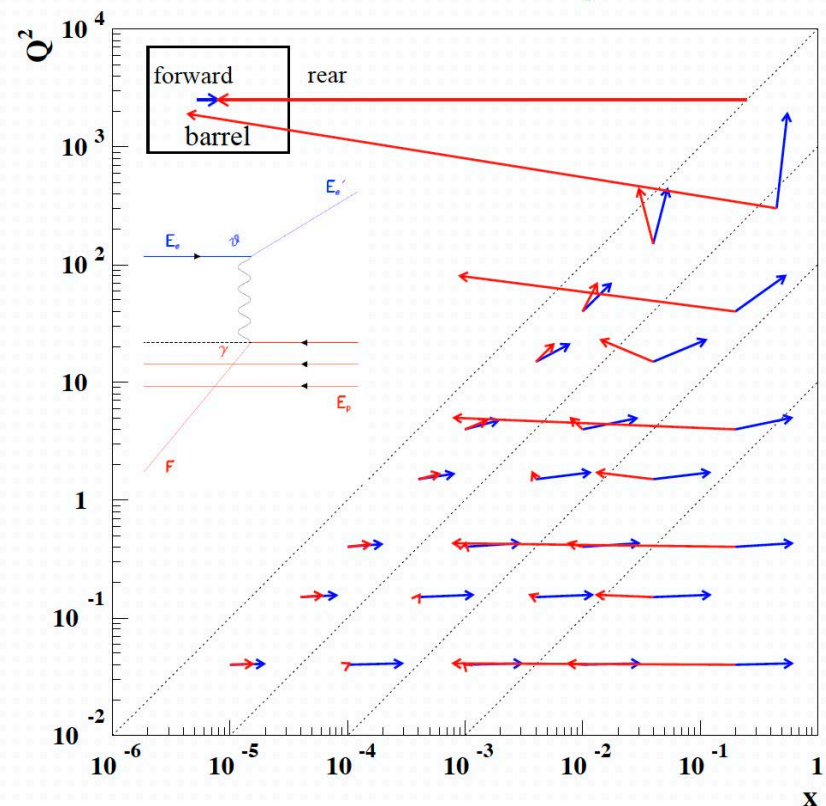
# Introduction

## □ Motivation

- At low/moderate  $Q^2$  and low  $x$ , both the current jet and electron have low energy, well below the actual beam energy (Here: 10GeV) and are found in the rear direction.
- Low dead material, precision energy, and precise hit localization are critical for precision kinematic variable reconstruction.
- This has been shown by the H1 and ZEUS experiments at HERA and will become even more challenging at an EIC facility due to smaller beam energies, in particular at high  $y$ .
- A triple-GEM forward/rear tracking system is ideal:
  - Provides needed precision hit localization directly in front / behind forward / rear calorimeter.
  - Aids in the understanding of pre-showering.
  - Dead material mapping.
  - Particle track / calorimeter mapping.
  - Provides hit points in front and behind a forward RICH (JLEIC).

- Proton
- Electron

EIC event topology ( $E_e=10$  GeV,  $E_p=250$  GeV)



# Introduction

## □ Overview of eRD3 effort

- R&D effort focuses on intermediate tracking system:
  - Barrel tracking system based on MM detectors (Dedicated barrel / curved MM EIC R&D program) manufactured as cylindrical shell elements and
  - Rear / Forward tracking system based on triple-GEM detectors manufactured as planar segments (Collaboration with eRD6 FIT/UVA) - Merging efforts!
- R&D effort - Main strategy:
  - Design and assembly of large cylindrical MM detector elements and large planar triple-GEM detectors
  - Test and characterization of MicroMegas and triple-GEM prototype detectors
  - Design and test of new, common chip readout system employing CLAS12 DREAM chip development
  - Utilization of light-weight materials
  - Development and commercial fabrication of various critical detector elements
  - Complete generic R&D phase (eRD3) and move to R&D phase in collaboration with eRD6

## eRD3 Status Report

eRD3 Progress Report FY17 / Proposal FY18

### EIC Detector R&D

### Progress Report FY17 and Proposal FY18

**Project ID:** eRD3

**Project Name:** Design and assembly of fast and lightweight forward tracking prototype systems for an EIC

**Period Reported:** January 2017 – July 2017 (Status) / FY18 (Proposal)

**Project Leaders:**  
Professor Bernd Surrow (Temple University) / Dr. Franck Sabatie (Saclay)

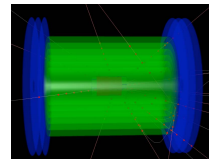
**Date:** July 16, 2017

**Applicant Address:** Temple University  
Department of Physics  
Science Education and Research Center  
1925 North 12th Street  
Philadelphia, PA, 19122

**Contact Person:** Professor Bernd Surrow

**Email:** surrow@temple.edu

**Phone:** 215-204-7644



# Introduction

## □ Highlights of triple-GEM R&D program

- CCD scanner components all machined and assembled / Commissioning in progress
- Kapton rings obtained - high quality / Test of various arrangements evaluated
- All GEM detector components available and tested: Single-mask GEM foils, HV foils, 2D readout foils, frames, Kapton spacer rings and soldering of SAMTEC multi-pin connectors to 2D readout foils
- All tooling available including new, large ultrasonic bath - fully operational
- GEM component storage unit - machining of components completed / Assembly in progress
- X-ray enclosure preliminary design available / Verification by TU safety group required / Quote of Pb-lined material available

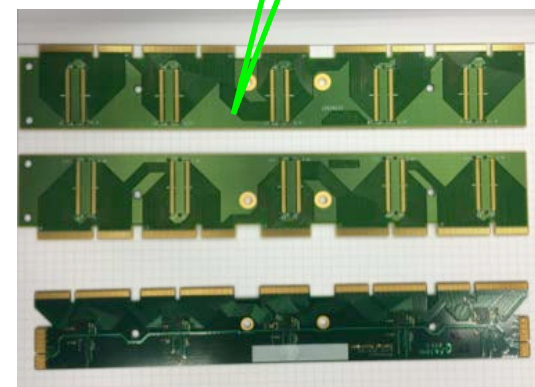
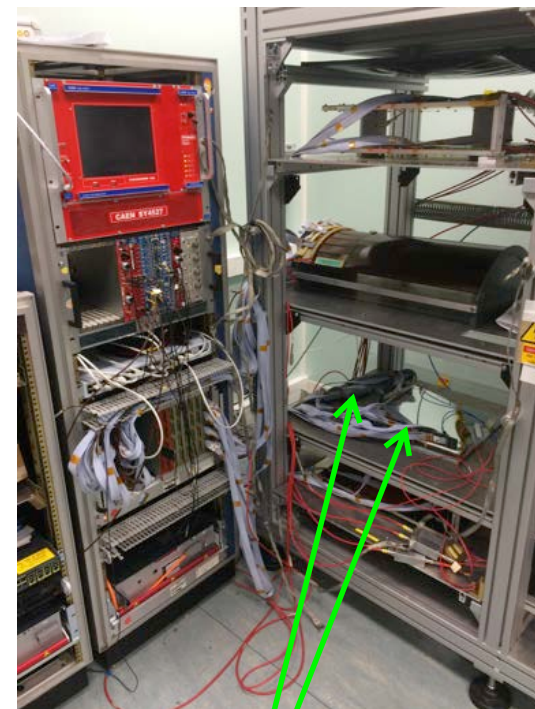




# Introduction

## □ Highlights of MM R&D program

- Further testing of MM 1D prototype detectors and triple-GEM prototype detector with DREAM chip readout
- Component list for DREAM-chip DAQ setup at Temple University available / No funding to proceed for now with independent DREAM-chip DAQ setup at Temple University
- Modular DREAM chip development as reported earlier
- 2D MM design ongoing / No funding to complete so far - Critical item for numerous applications as part of original generic eRD3 R&D program





# Introduction

## International MPGD 2017 Conference / RD51 Collaboration Meeting

- MPGD2017 mainly focuses on micro-pattern gas detector and related technologies, future applications at nuclear/particle physics facilities, and commercial production/applications
- Took place: May 22-26, 2017 at Temple University
- Local organizing committee (Several eRD3/6 members): Member institutions: BNL / Florida Institute of Technology / Stony Brook University / Temple University / University of Virginia / Yale University
- Selection of eRD3/6 to host MPGD2017 ⇒ Strong recognition of EIC R&D program!
- "In recent years, we have seen a growing and impactful community participating in MPGD established in the US."

—S. Dalla Torre, MPGD 2017



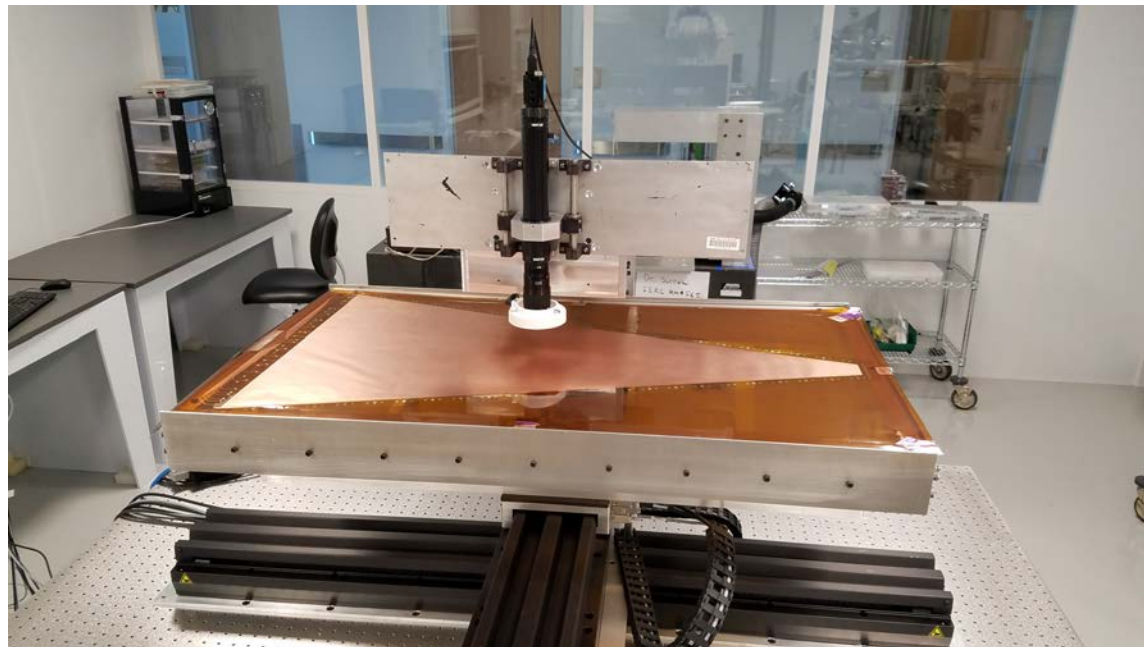
<https://phys.cst.temple.edu/mpgd2017/>





# Status - Forward GEM Tracking / Generic R&D

## □ GEM CCD Scanner

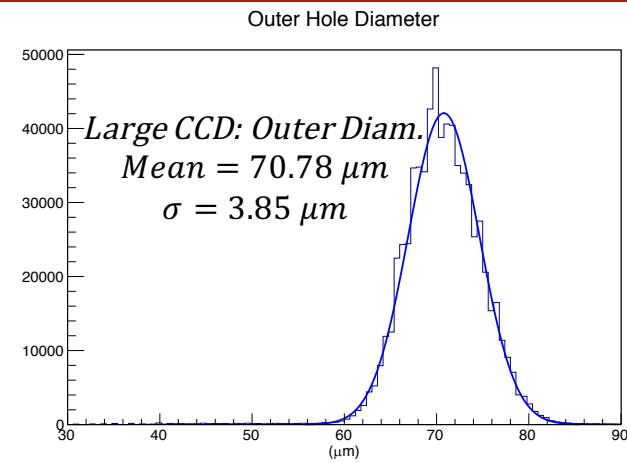
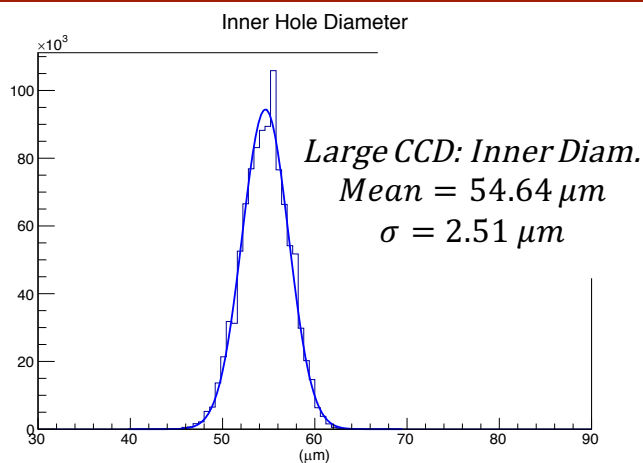
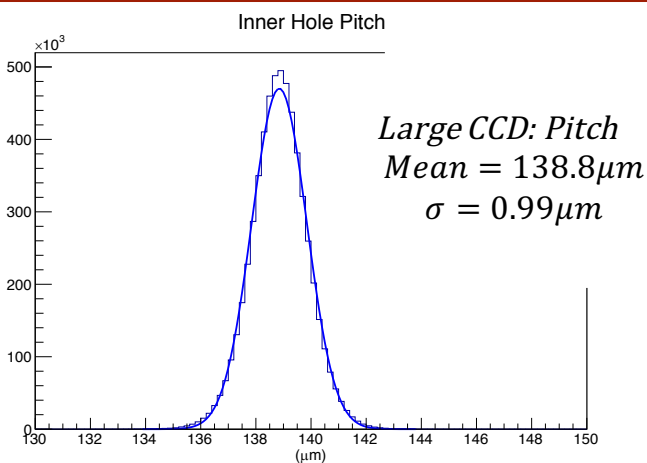
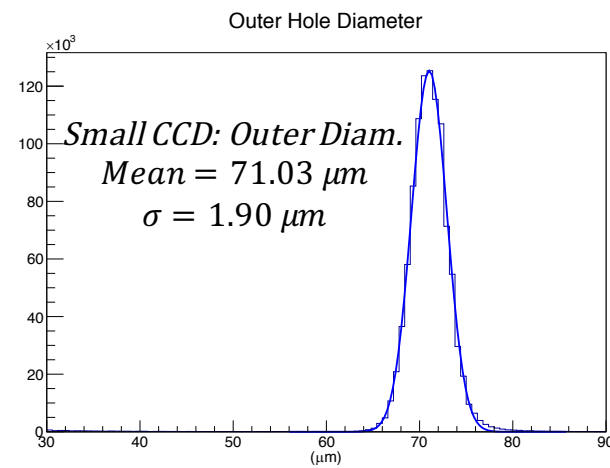
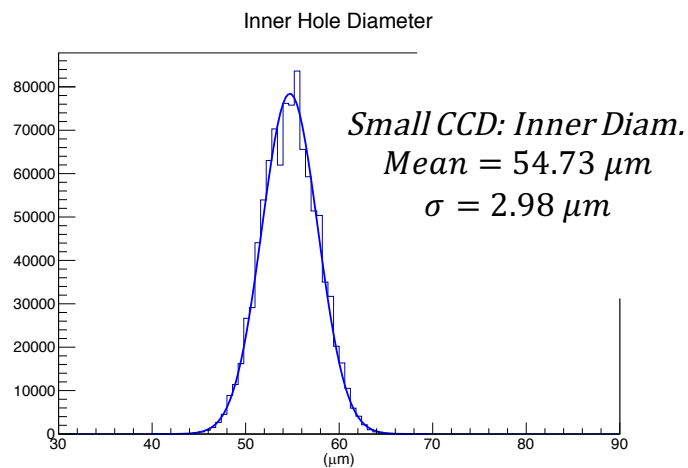
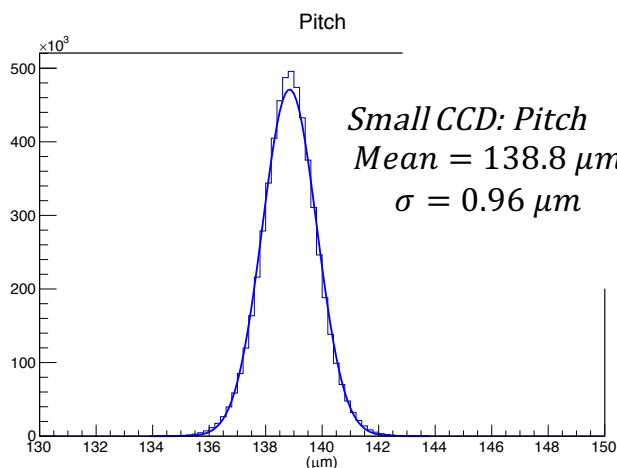


- CCD scanner components all machined and assembled / Commissioning completed!
- Design similar to prior setup based on glass support, top and bottom light with fixed new CCD camera under MatLab control
- Significant extension in size to allow scans of GEM foils of size of max. ~60cm / ~120cm
- 3 initial foil sizes have been scanned: 10x10cm<sup>2</sup>, 40x40cm<sup>2</sup>, 60x100cm<sup>2</sup>
- Scans are in agreement with previous measurements and software image analysis is now being optimized.
- Scan of existing foils and larger EIC / CMS foils planned.



# Status - Forward GEM Tracking / Generic R&D

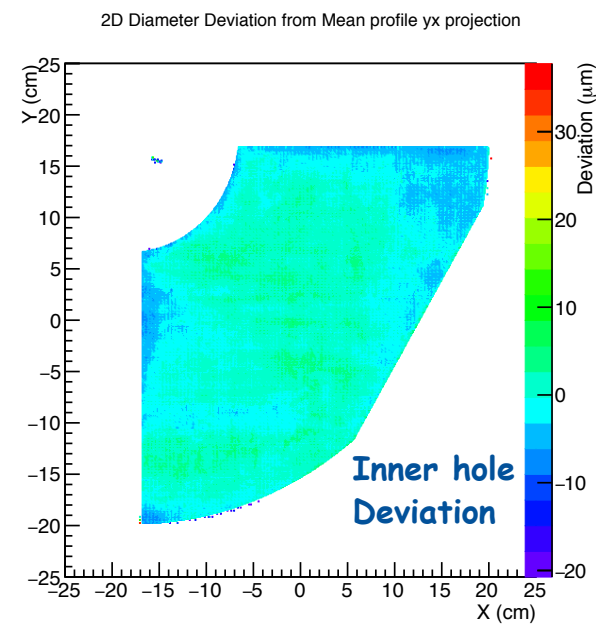
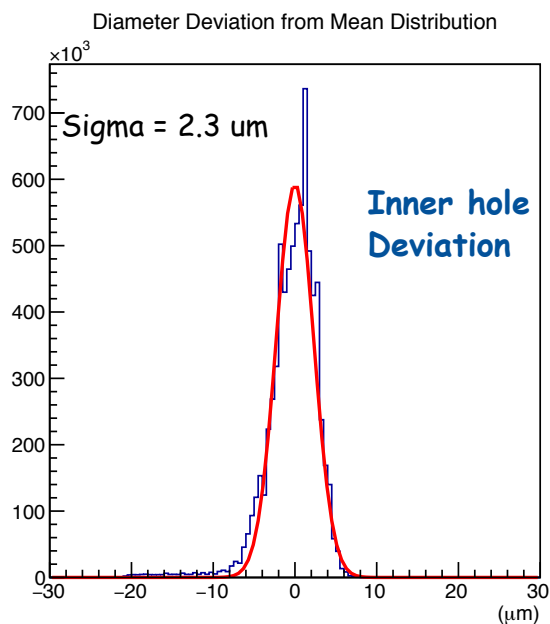
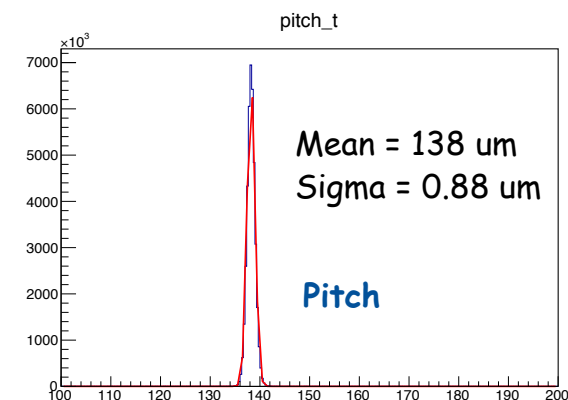
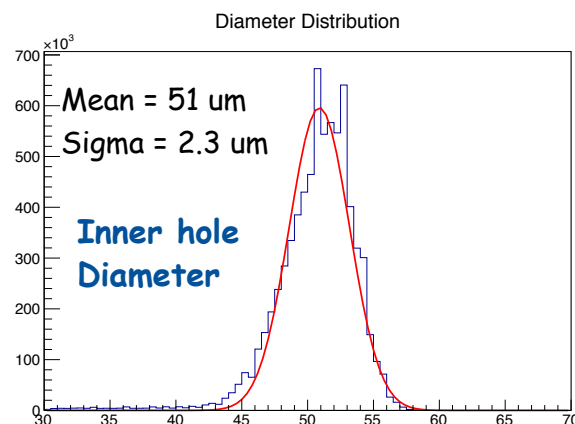
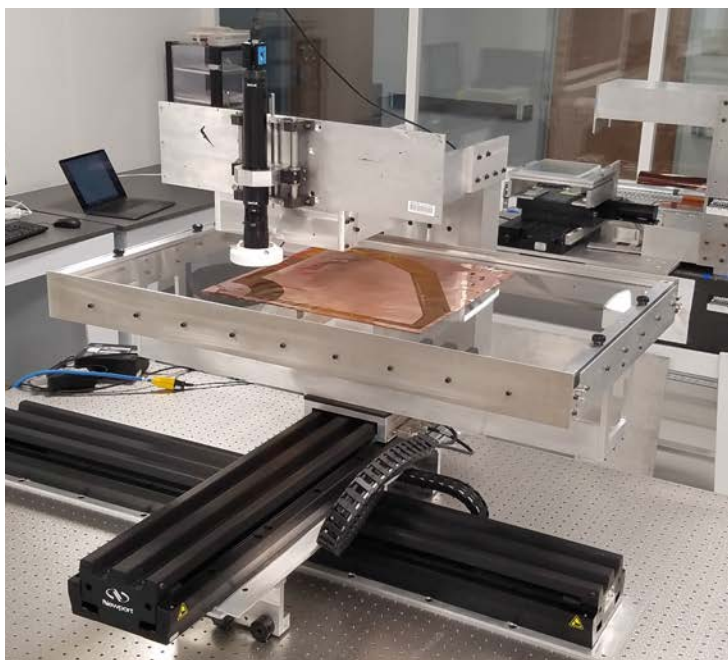
## GEM CCD Scanner - Initial Commissioning Results (10cm X 10cm)



# Status - Forward GEM Tracking / Generic R&D

## GEM CCD Scanner - Initial Commissioning Results (40cm X 40cm)

- Inner hole measurements consistent with previous small area CCD measurements
- Outer hole diameter commissioning is now under analysis



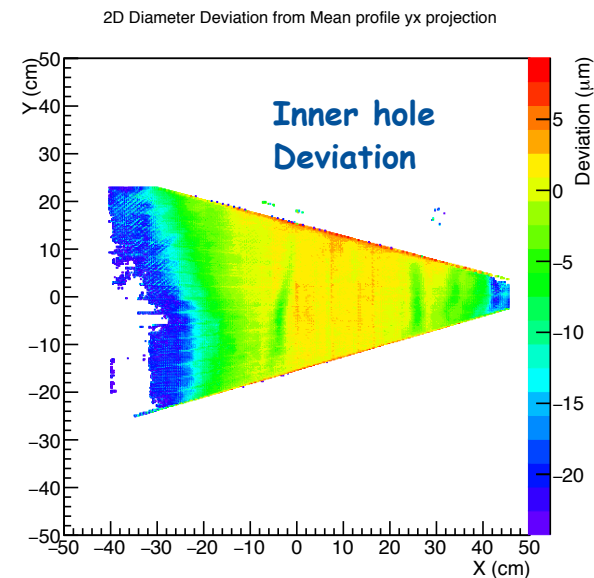
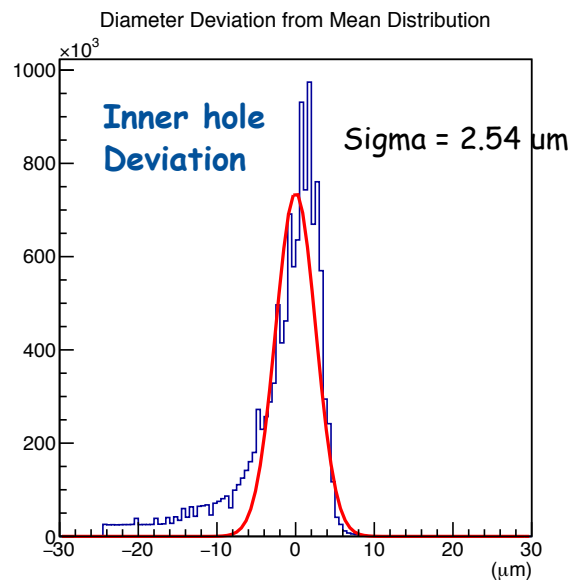
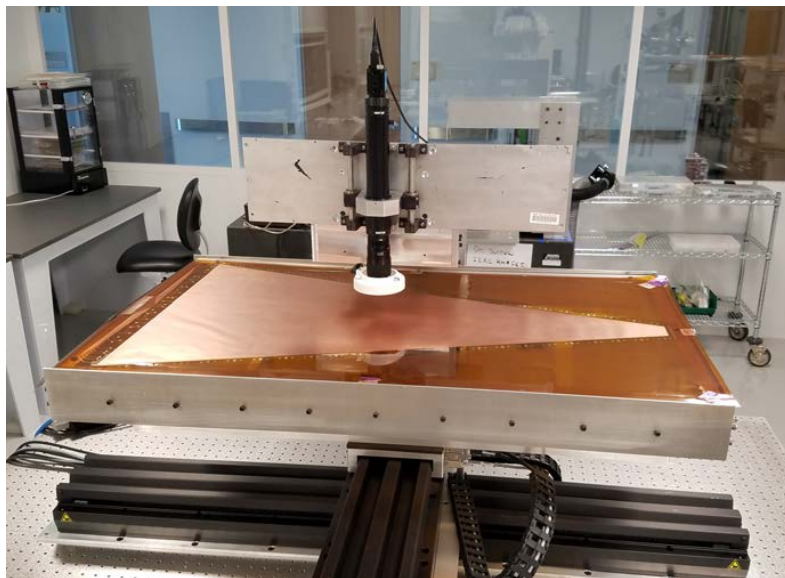
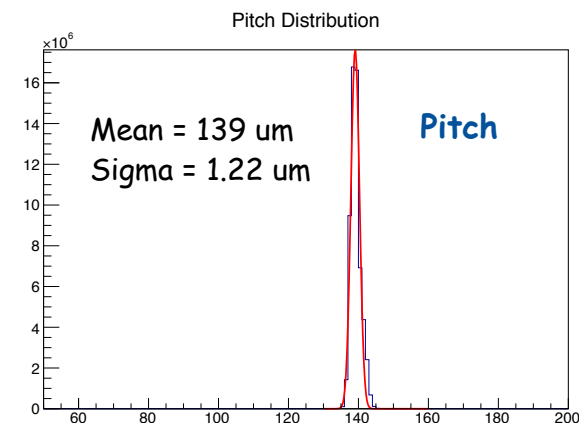
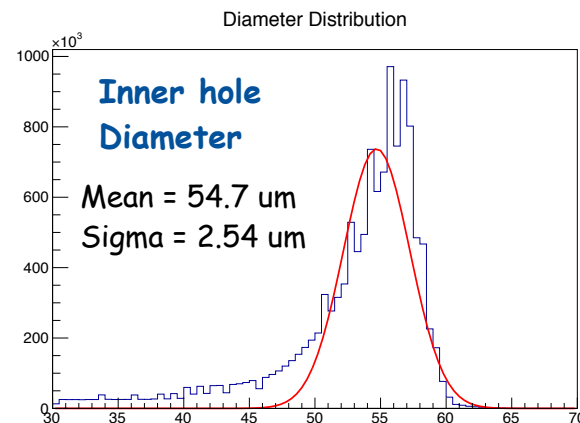
# Status - Forward GEM Tracking / Generic R&D

## GEM CCD Scanner - Initial EIC "Common Foil" Commissioning Results (60cm X 100cm)

○ CCD camera experienced focussing issues during the EIC foil scan which resulted in smaller inner hole diameters.

○ Issue has now been addressed by implementing thick glass bed. Scans on-going for verification.

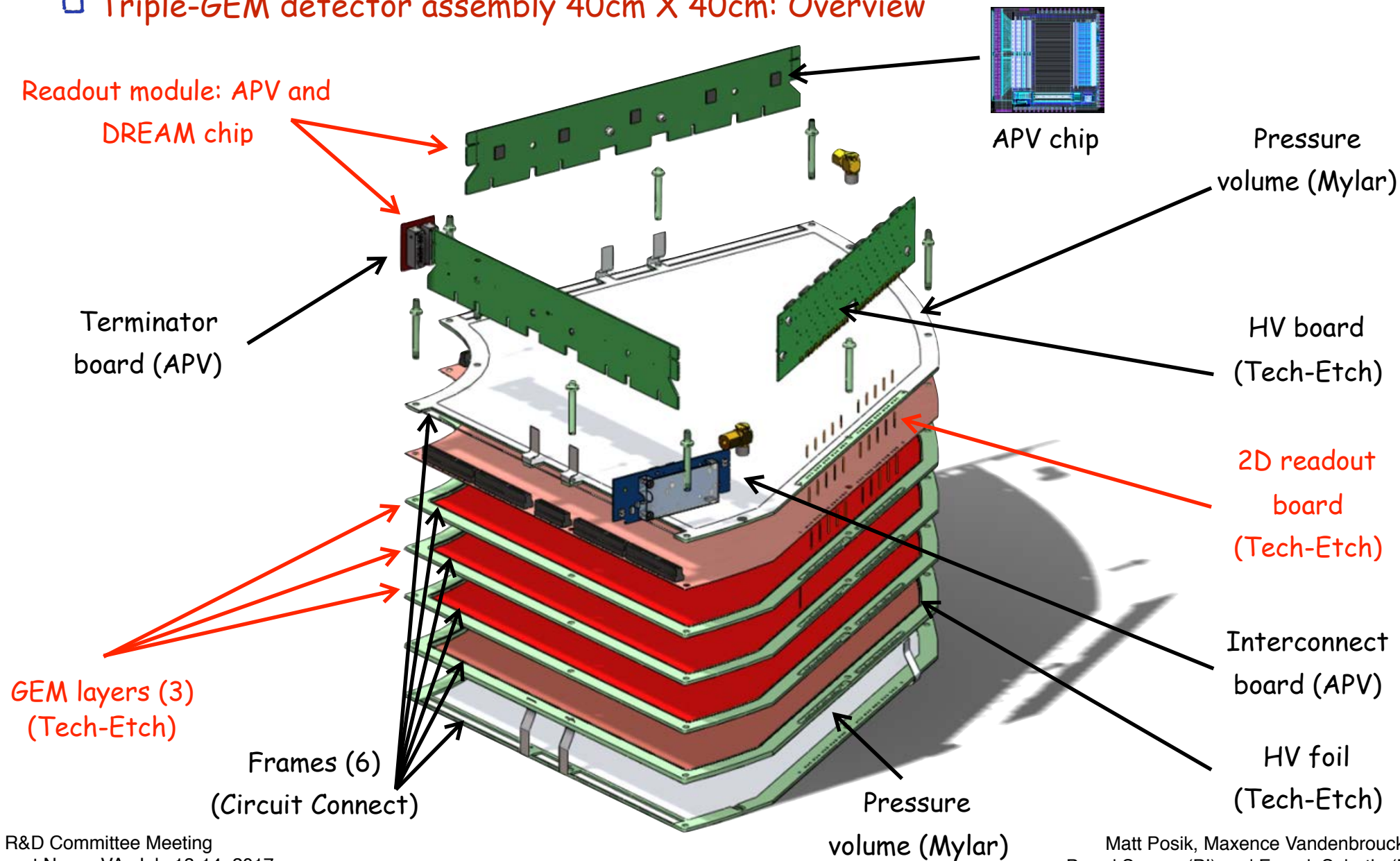
○ Outer diameter scans to follow.





# Status - Forward GEM Tracking / Generic R&D

## Triple-GEM detector assembly 40cm X 40cm: Overview



# Status - Forward GEM Tracking / Generic R&D

## Triple-GEM detector assembly 40cm X 40cm: Kapton rings and arrangements



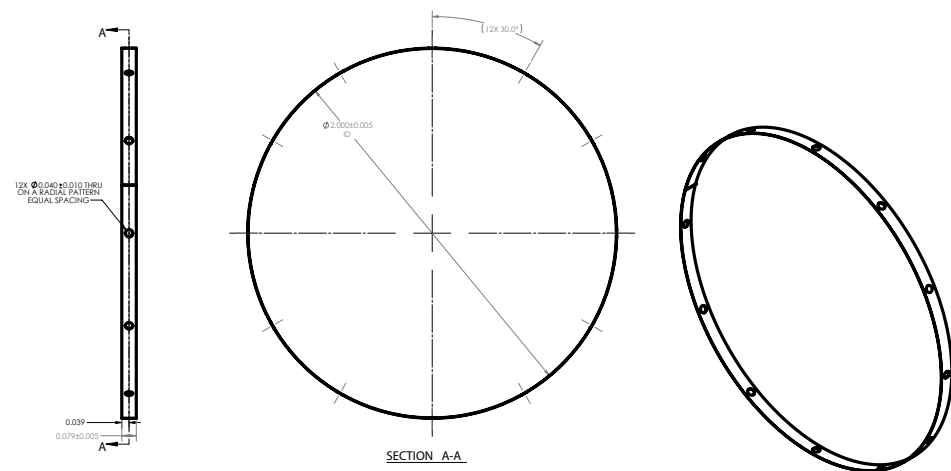
Kapton rings: 2"

- Kapton rings of high quality 2" with gas holes received from **Potomac Photonics Inc.**

- Wall thickness **0.127 mm**

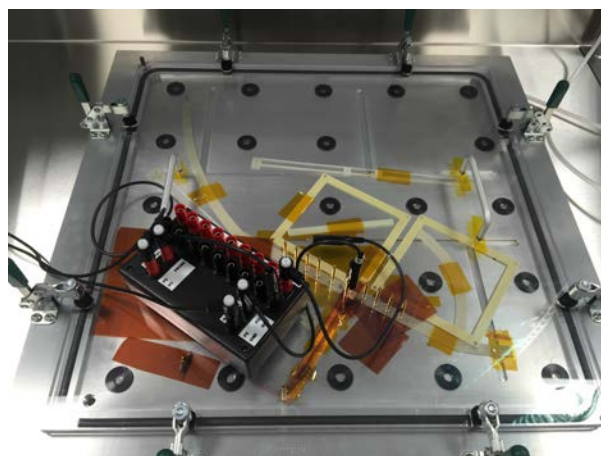
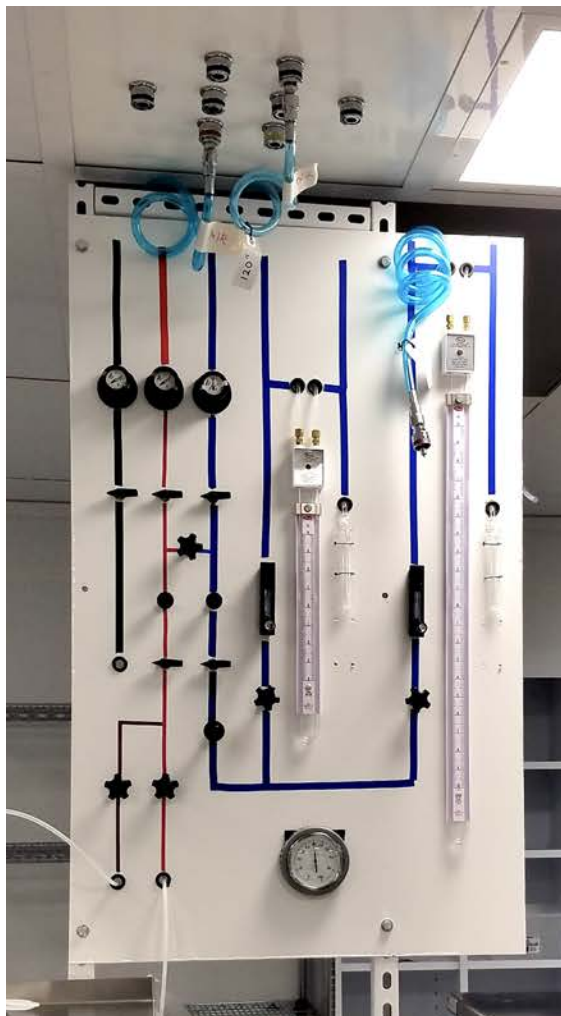
- Test of arrangements completed / Handling very simple

- Initial arrangements decided

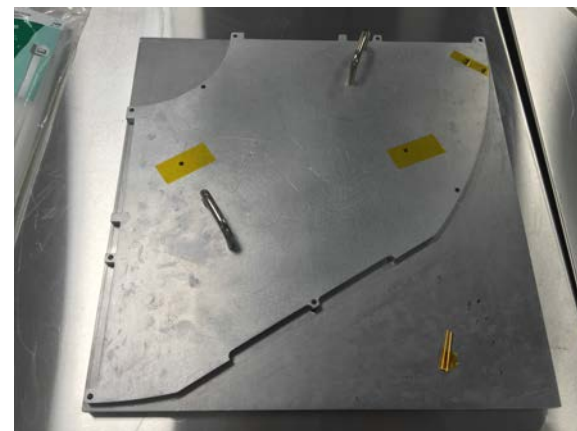


# Status - Forward GEM Tracking / Generic R&D

## □ Triple-GEM detector assembly 40cm X 40cm: Tooling 1



GEM nitrogen box / N<sub>2</sub> enclosure



Assembly tool with gas flow cover



ISEG precision power supply and current measurement

○ All detector assembly will be carried out in the TU micro pattern class 1000 clean room facility.

○ 3 gas sources are available

○ Dry air (stretched/glue dispenser)

○ Nitrogen (electrical tests/GEM storage)

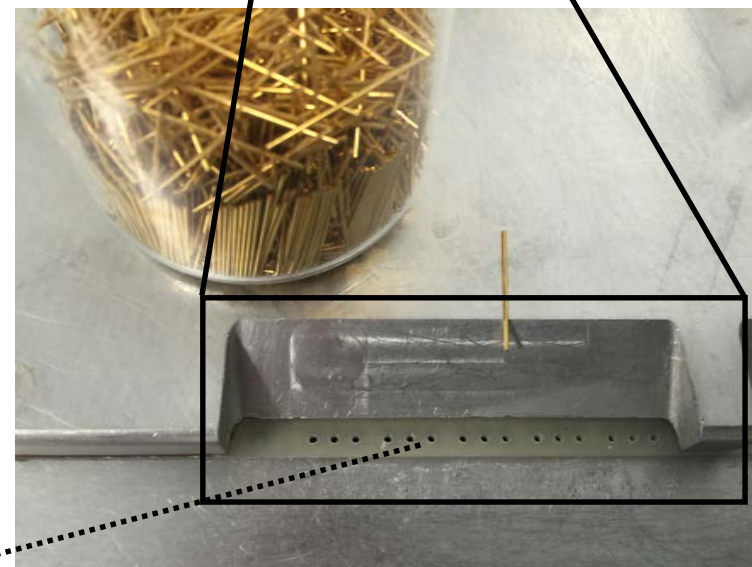
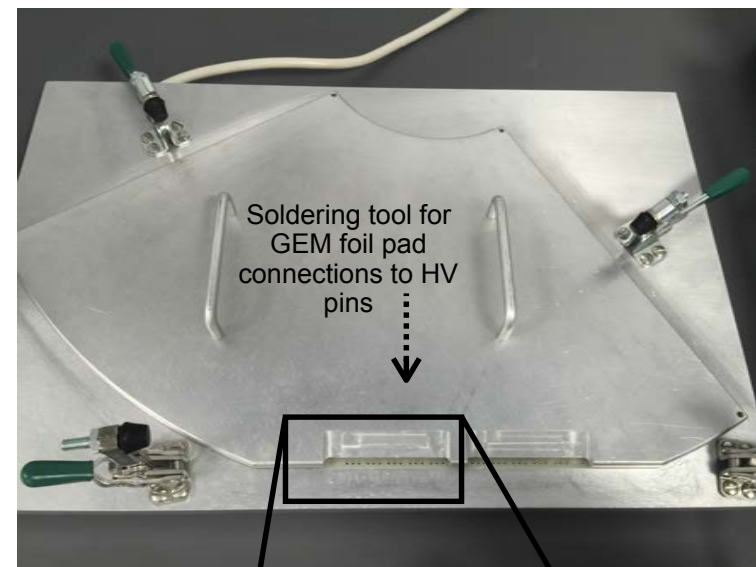
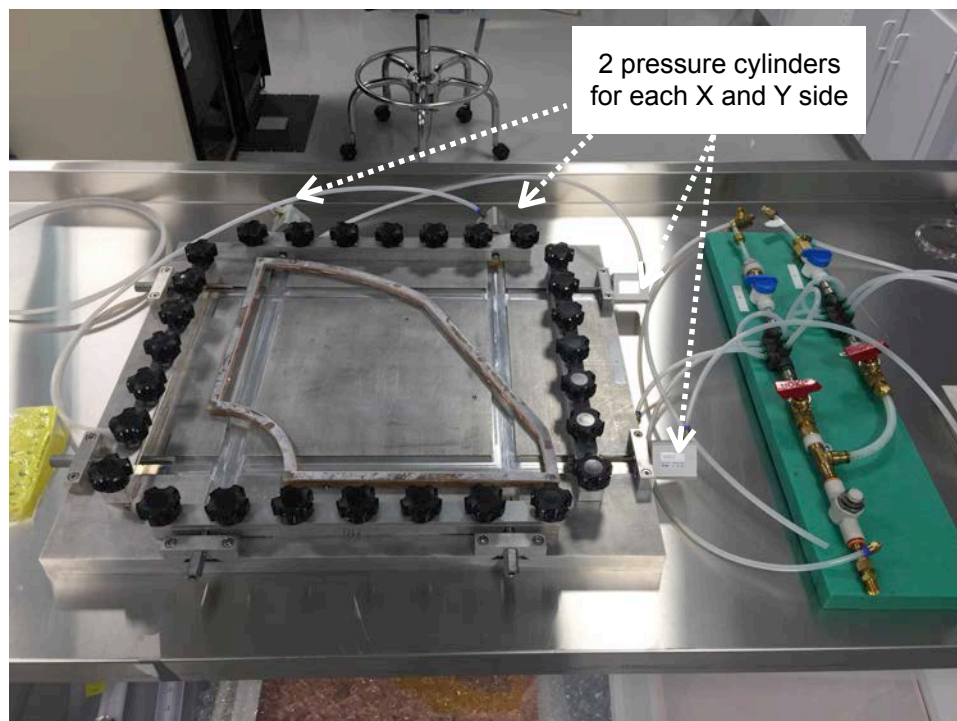
○ Argon (leakage tests)

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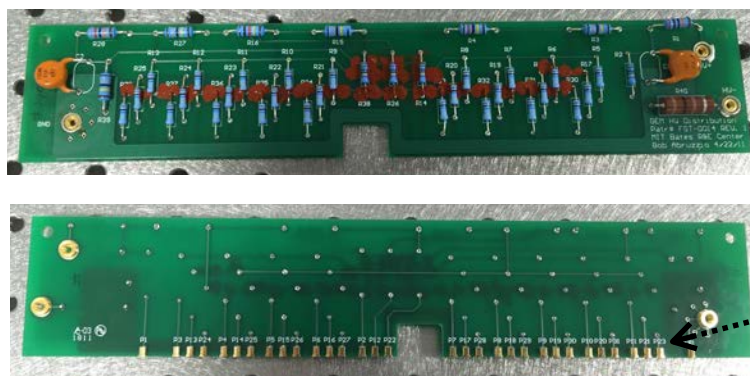


# Status - Forward GEM Tracking / Generic R&D

## Triple-GEM detector assembly 40cm X 40cm: Tooling 2



HV boards



# Status - Forward GEM Tracking / Generic R&D

- ❑ Triple-GEM detector assembly 40cm X 40cm: Tooling 3
  - Large ultra-sonic bath (215 L) available and commissioned/cleaning procedure established
  - Basket large enough to allow cleaning of frames for EIC size frames





# Status - Forward GEM Tracking / Generic R&D

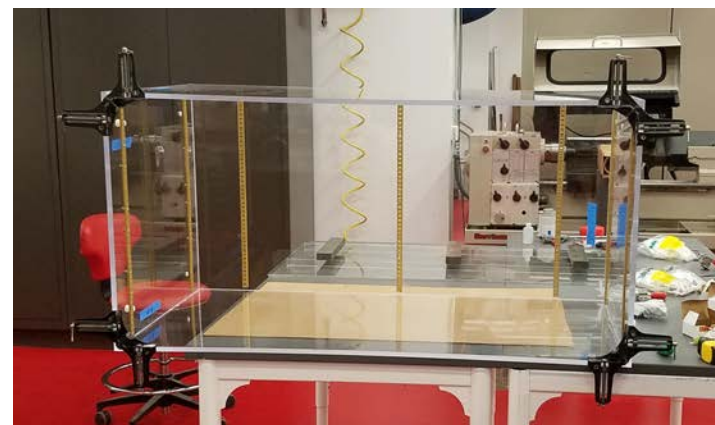
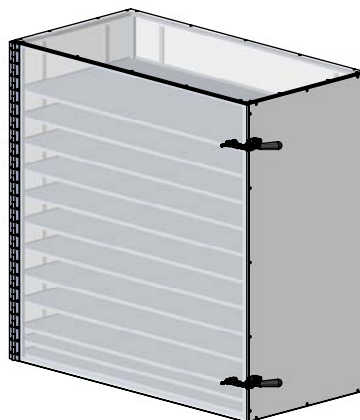
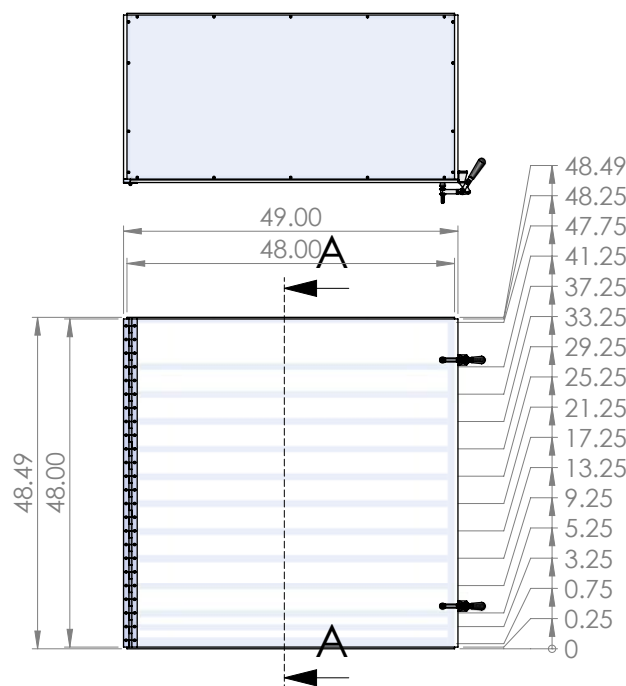
## Triple-GEM detector assembly 40cm X 40cm: Tooling 4

- Design of large GEM storage unit completed featuring multiple large shelves to accommodate EIC type components

- Original design split into two boxes

- Material: Lucite material

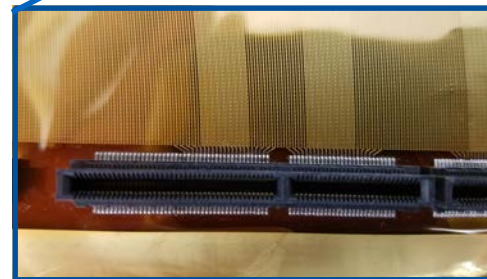
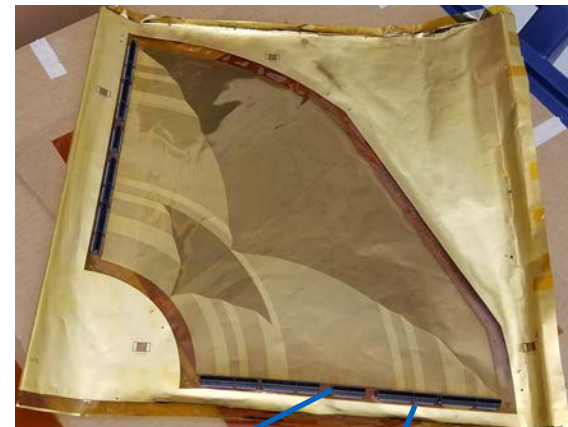
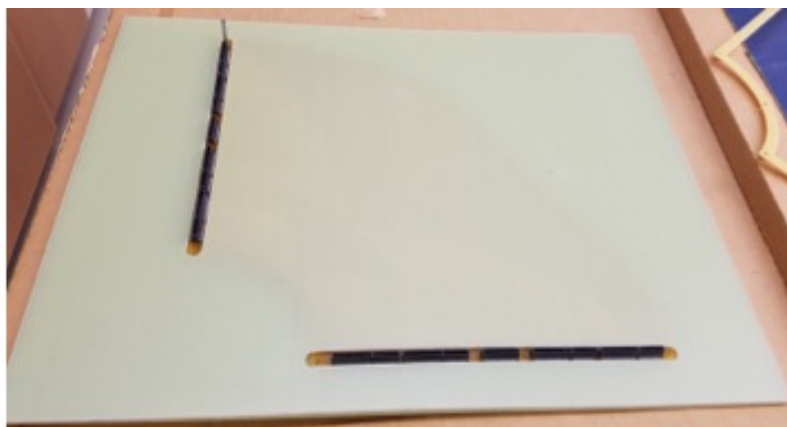
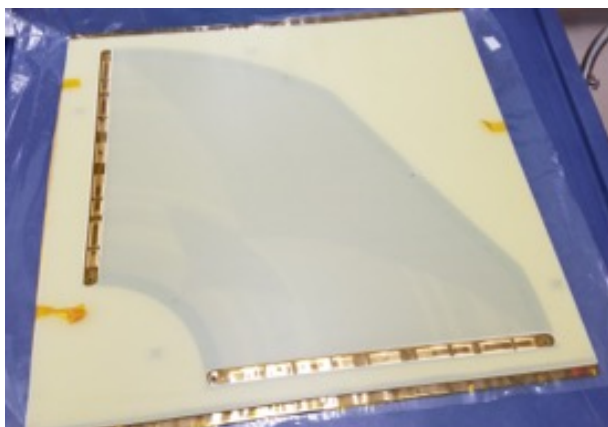
- Machining/assembly nearing completion in local machine shop





## Status - Forward GEM Tracking / Generic R&D

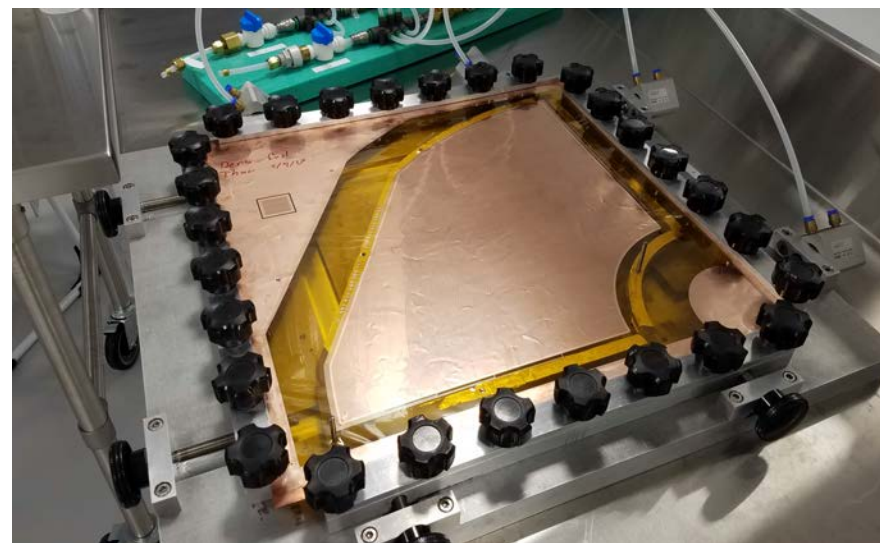
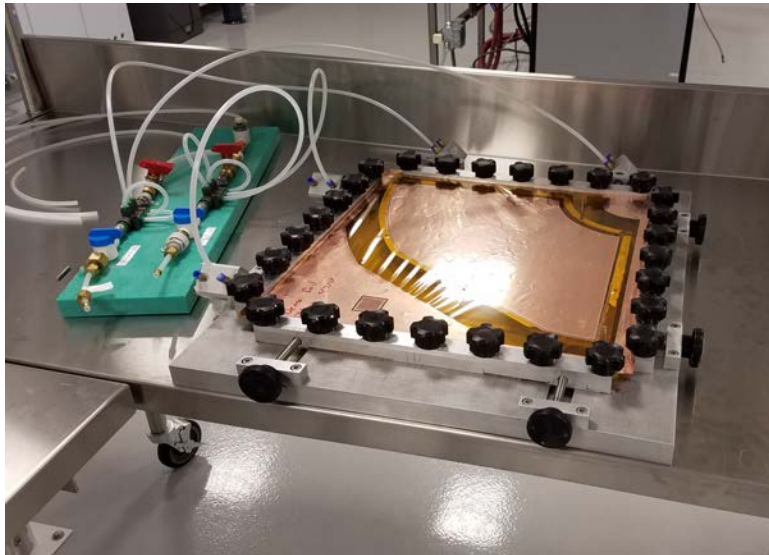
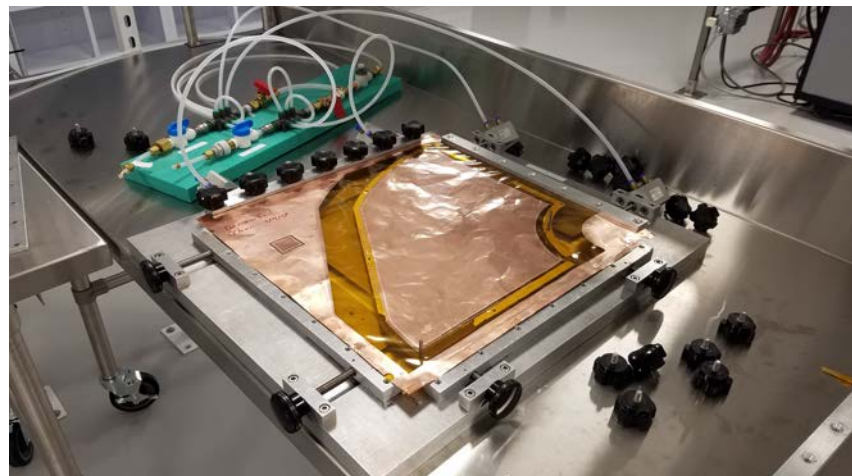
- Triple-GEM detector assembly 40cm X 40cm: 2D readout foils / FEE



- All 2D readout foils available
  - Commercial soldering of multi-pin connectors completed by **Proxy Inc.**
  - 2D readout foils produced by **Tech-Etch**
- are **independent** of GEM production facility

# Status - Forward GEM Tracking / Generic R&D

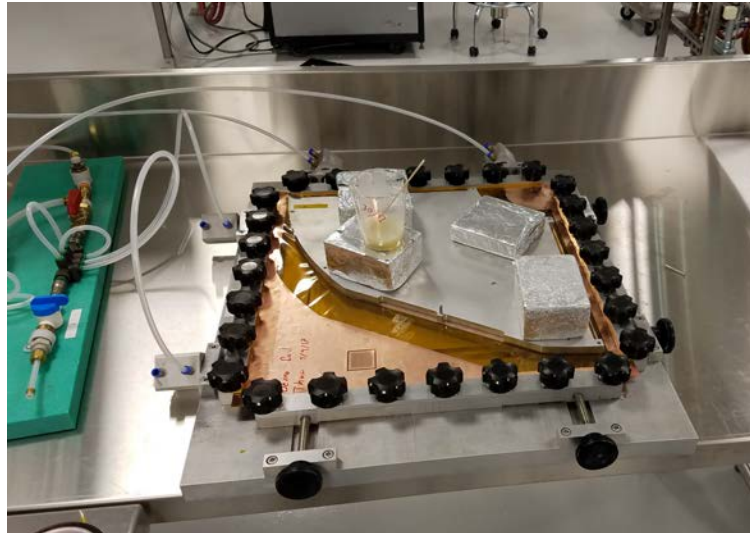
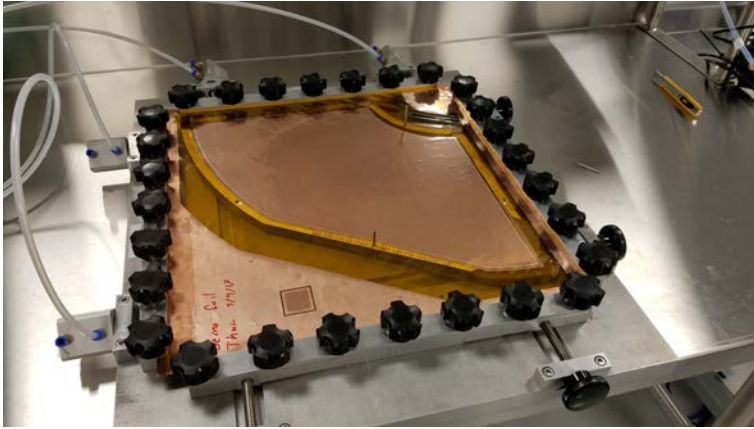
## □ Triple-GEM detector assembly 40cm X 40cm: Stretching Practice





# Status - Forward GEM Tracking / Generic R&D

## Triple-GEM detector assembly 40cm X 40cm: Glueing Practice

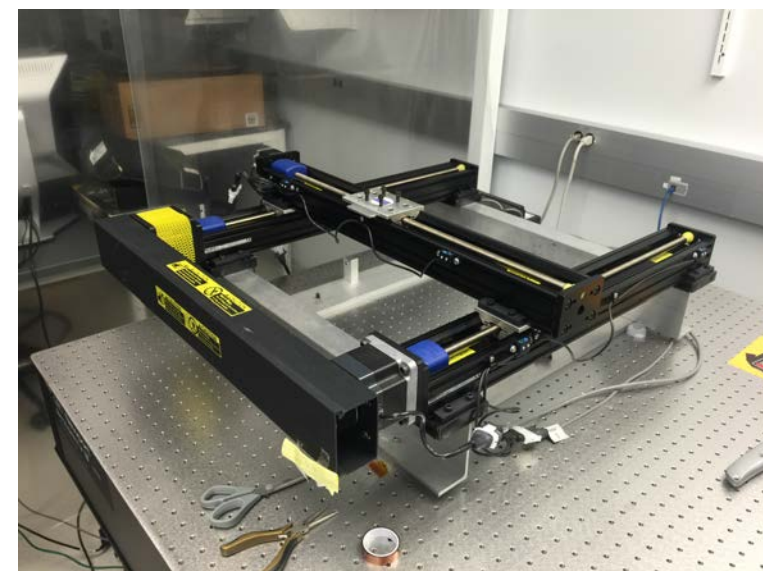




# Status - Forward GEM Tracking / Generic R&D

## □ X-ray Scanning

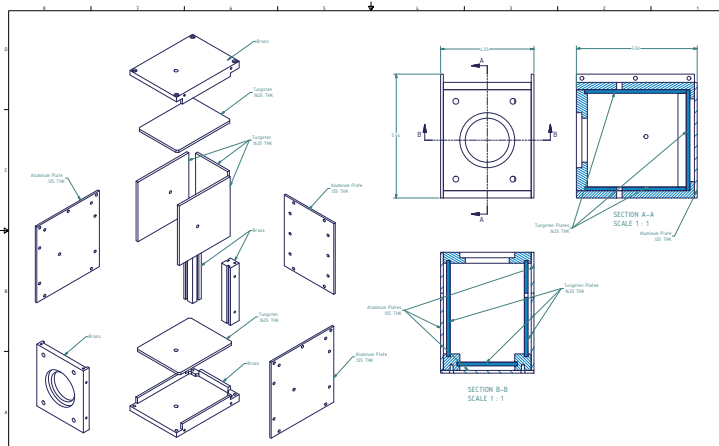
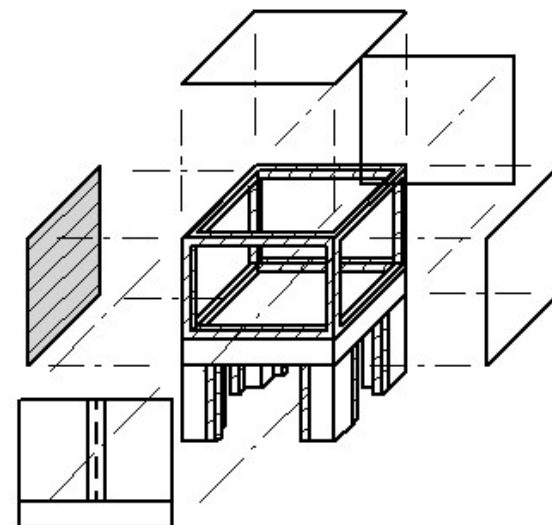
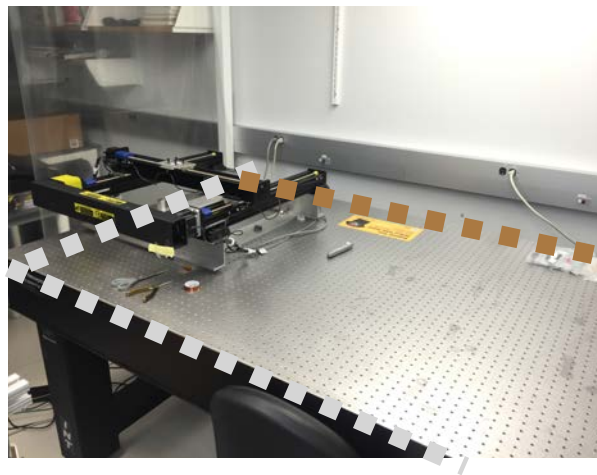
- Use X-Y gantry and X-ray source (x-ray gun and Fe-55) to measure the gains as a function of detector position.
- Mini X-ray gun to be used to test detector efficiency/gain (already purchased)
  - Au target, 50 keV energy
- Current X-Y stages allows for scanning of 40 cm x 40 cm detectors.
- X-Y gantry built on 4'x6' optical table inside the GEM detector lab
- Future upgrade planned to larger scanning device similar to CCD scanner after successful operation of current gantry.



# Status - Forward GEM Tracking / Generic R&D

## X-ray enclosure

- Need radiation enclosure to operate X-ray gun
- 2 designs being considered:
  1. Enclose entire table
    - Preliminary design work for enclosure completed
    - Quote received by Nelco for Pb-lined plywood / one side Pb-glass
  2. Enclose only X-ray gun
    - Investigation surrounding only the gun, which is used at BNL by eRD6
    - Awaiting quote



X-ray gun

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Bernd Surrow (PI) and Franck Sabatie (PI)



## Status - Forward GEM Tracking / Generic R&D

### □ Commercial component development

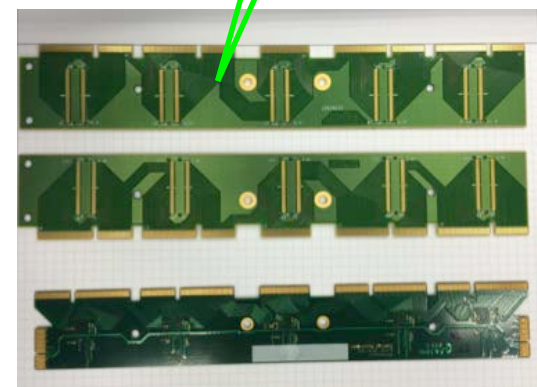
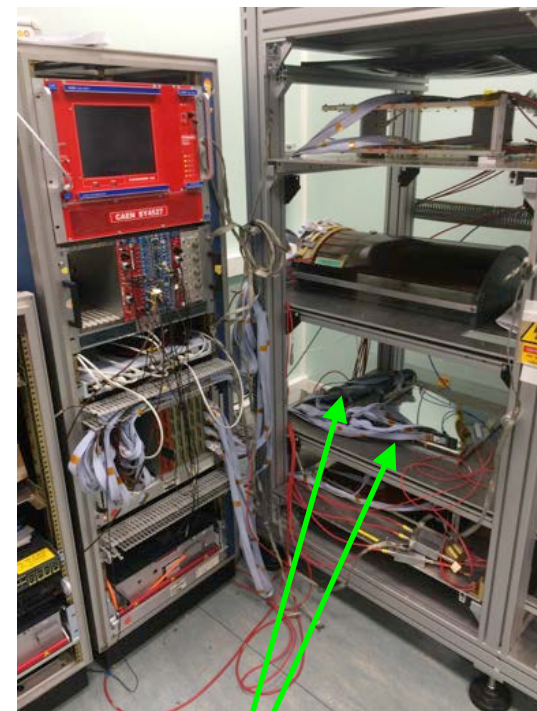
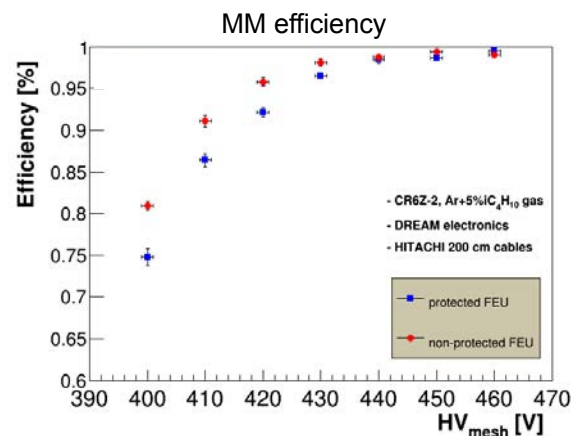
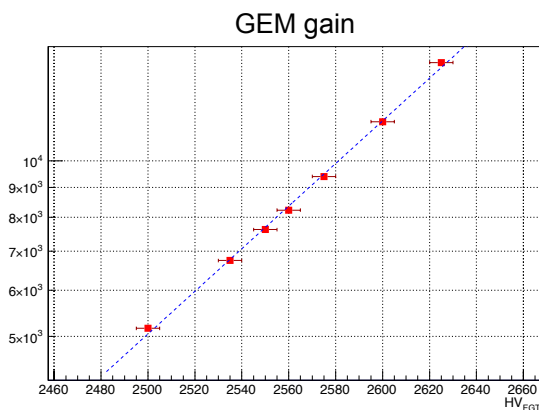
- GEM foils: **Tech-Etch Inc.** (Continuation of effort of GEM foils will depend on large scale orders - Paused for the moment as directed by Board of Directors and President)
  - GEM foils: **Silver Side Detectors** (New SBIR proposal - Positively reviewed, but not funded as of now!)
- HV foils: **Tech-Etch Inc.** - Continuing!
- 2D readout foils: **Tech-Etch Inc.** - Continuing!
- 2D readout foil / connector soldering: **Proxy Inc.**
- Readout module (APV) / Passive DREAM readout card: **Sierra Circuits Inc.**
- Frames: **Circuit Connect Inc.**
- Kapton rings: **Potomac Photonics Inc.**



# Status - Barrel MM tracking / Generic R&D

## □ DREAM chip readout system: MM / GEM

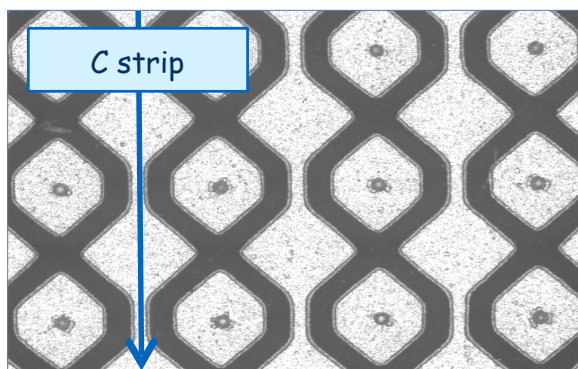
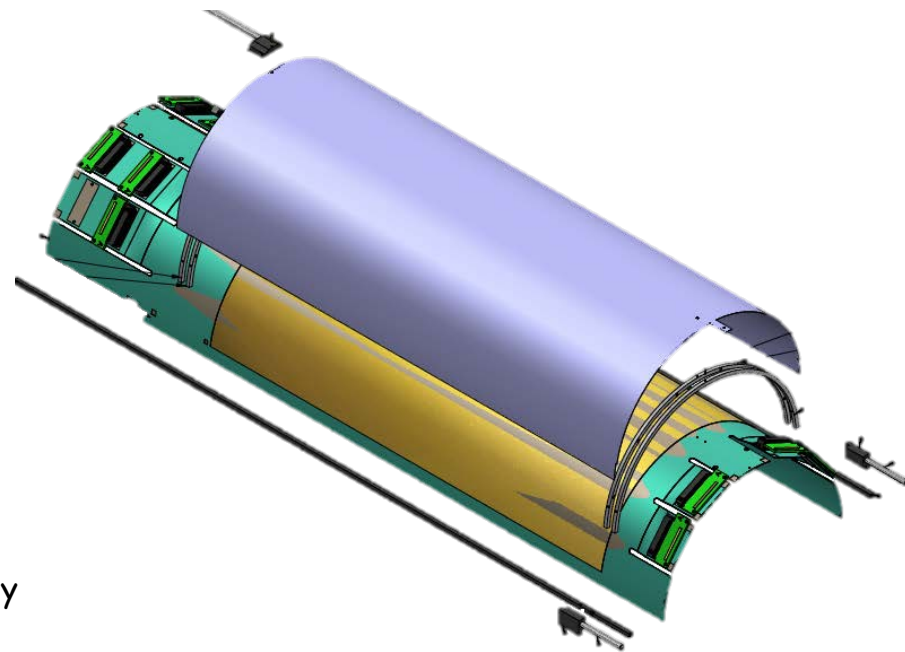
- Further testing of MM 1D prototype detectors and triple-GEM prototype detector with DREAM chip readout
- Component list for DREAM-chip DAQ setup at Temple University available / No funding to proceed for now with independent DREAM-chip DAQ setup at Temple University
- Modular DREAM chip development as reported earlier
- Further development of modular DREAM readout system
- 2D MM design ongoing / No funding to complete so far - **Critical item** for numerous applications as part of original generic eRD3 R&D program



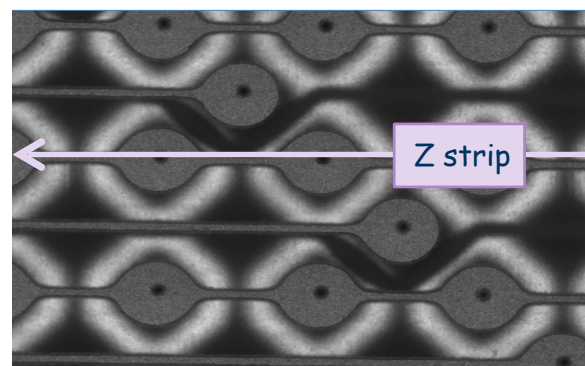
# Plans - Barrel MM tracking / Generic R&D

## □ Barrel MM effort

- **Main goal:** 2D design completion
- Next technological step after 1D-curved-resistive, 2D-curved-metallic and 2D-flat-resistive
- Will profit from experience with CLAS12, Asacusa AMT and Mcube
- Complete design of 2D MM prototype detectors followed by ordering of components, assembly and testing



Read-out pattern (top)



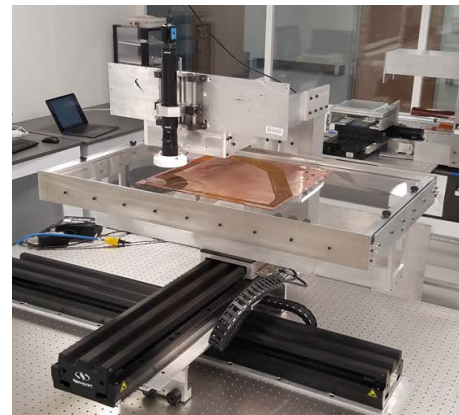
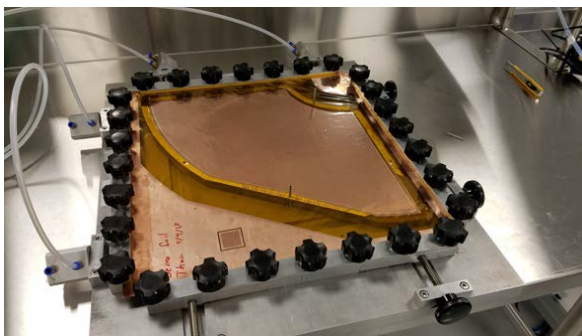
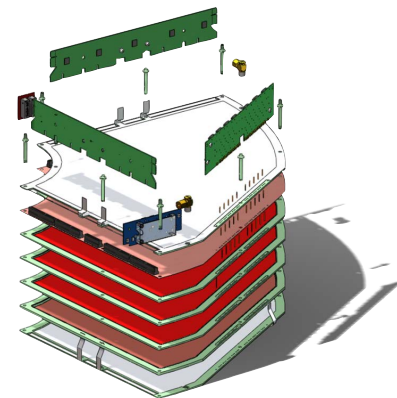
Read-out pattern (bottom)

# Plans - Forward GEM Tracking / Generic R&D

## □ Forward GEM Tracking

○ **Main goal:** Complete / Test generic R&D (Commercial triple-GEM detector) → **publication**

- **Triple-GEM assembly:** All materials acquired and experience gained through practice run using old components.
- **Testing (I):** Includes leakage current and gas leak testing / cosmic-ray testing (Efficiency)
- **Testing (II):** Test gain and energy resolution with Fe-55 source (need to purchase **critical**)
- **Testing (III):** Use mini X-ray gun (already purchased) to test gain/efficiency. Need to purchase radiation enclosure material to operate x-ray gun.
- **Testing (IV):** If timing is right and the opportunity presents itself we could also test the detector at a test beam.





# Status - Forward GEM Tracking / Generic R&D

## □ Triple-GEM detector assembly 40cm X 40cm

- ☒ All materials acquired and all GEM foils tested and ready to be stretched.
- ☒ Gas distribution system installed
- ☒ Soldering of multipoint connectors to 2D readout foils.
- ☒ GEM frame cleaning procedure established and commissioned.
- ☒ GEM stretching, gluing, soldering and stack assembly procedures in place.
- ☐ GEM storage boxes completed/installed
- ☐ Stretching/gluing of GEM, HV, and readout foils
- ☐ Assembly of triple-GEM detector, with leakage current testing between each assembly step.
- ☐ Begin testing (cosmics, Fe-55, x-ray gun)

Timeline

DONE

DONE

DONE

DONE

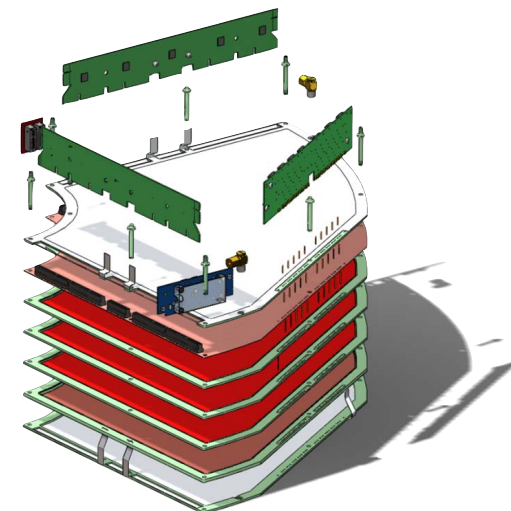
DONE

In progress (July)

July / August 2017

August 2017

Fall 2017



Commissioned cosmic-ray test stand



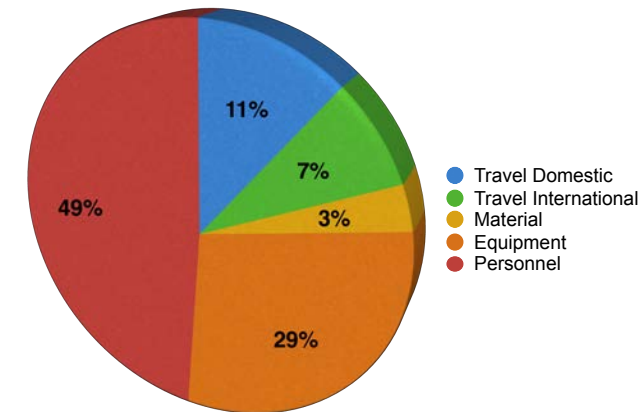
Matt Posik, Maxence Vandenbroucke,  
Bernd Surrow (PI) and Franck Sabatie (PI)

# Budget request FY18

## Generic R&D request / Complete by FY18 (1)

- Highest priority: 50% postdoc support for 2nd / final year
- Travel support: \$8,250 (Domestic) + \$5,600 (International)
- Material: \$2,500 (GEM Assembly)
- Equipment: \$22,000 (55Fe Source / X-ray enclosure and MM 2D Assembly)
- Total: \$104,531 (Incl. 56% overhead)

DOE EIC R&D / eRD3 - Dr. Bernd Surrow (PI) (Temple University)	
	FY 2018
<b>PERSONNEL</b>	
Post Docs (50%)	\$28,184
Fringe Benefits	
29.7% on Post Doc	\$8,371
<b>Total Personnel</b>	<b>\$36,555</b>
<b>Travel - Domestic</b>	<b>\$8,250</b>
<b>Travel - International</b>	<b>\$5,600</b>
<b>Material</b>	<b>\$2,500</b>
<b>Equipment</b>	<b>\$22,000</b>
<b>OTHER:</b>	
<b>Total Direct Costs</b>	<b>\$74,905</b>
<b>Modified Total Direct Costs (MTDC)</b>	<b>\$52,905</b>
<b>F&amp;A: On-Campus Overhead 56%</b>	<b>\$29,627</b>
<b>Total Project Costs</b>	<b>\$104,531</b>



# Budget request FY18

## □ Generic R&D request / Complete by FY18 (2)

### ○ R&D categories:

	R&D Subproject 1: GEM Assembly	R&D Subproject 2: 55Fe Source/X-ray Enclosure	R&D Subproject 3: MM 2D Assembly	Travel (Domestic)	Travel (International)	Postdoc Support	Total:
Temple University	\$2,500	\$10,000	\$0	\$8,250	\$5,600	\$36,555	\$62,905
Saclay	\$0	\$0	\$12,000	\$0	\$0	\$0	\$12,000
<b>Total Direct Costs</b>	\$2,500	\$10,000	\$12,000	\$8,250	\$5,600	\$36,555	\$74,905
<b>MTDC</b>	\$2,500	\$0	\$0	\$8,250	\$5,600	\$36,555	\$52,905
<b>F&amp;A Overhead 56%</b>	\$1,400	\$0	\$0	\$4,620	\$3,136	\$20,471	\$29,627
<b>Total Project Costs</b>	\$3,900	\$10,000	\$12,000	\$12,870	\$8,736	\$57,025	\$104,531

### ○ Budget scenarios:

○ Nominal: GEM assembly + 55Fe Source / X-ray Enclosure + MM 2D + Travel + 50% Postdoc

Support → \$104,531

○ ~20% Lower: 55Fe Source / X-ray Enclosure + Travel + 50% Postdoc Support → \$88,631

○ ~40% Lower: 55Fe Source / X-ray Enclosure + 50% Postdoc Support → \$67,025



# Summary / Outlook

## □ Summary / Outlook

### ○ Forward GEM tracking

#### □ Generic R&D:

- Acquired all components and prepared tooling for 40cm X 40cm assembly / Assembly and testing underway
- Design of CCD scanner assembled and operational for different GEM foil sizes
- Design of X-ray enclosure underway / Urgently needed for operation of existing X-ray gun

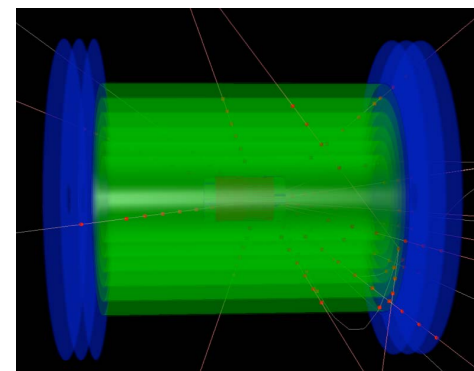
### ○ Barrel MicroMegas tracking

- **Generic R&D:** Design and assembly of 2D MM - Critical step to complete eRD3 R&D program / Funding required!

### ○ Fully merge eRD3/6 efforts beyond generic R&D programs

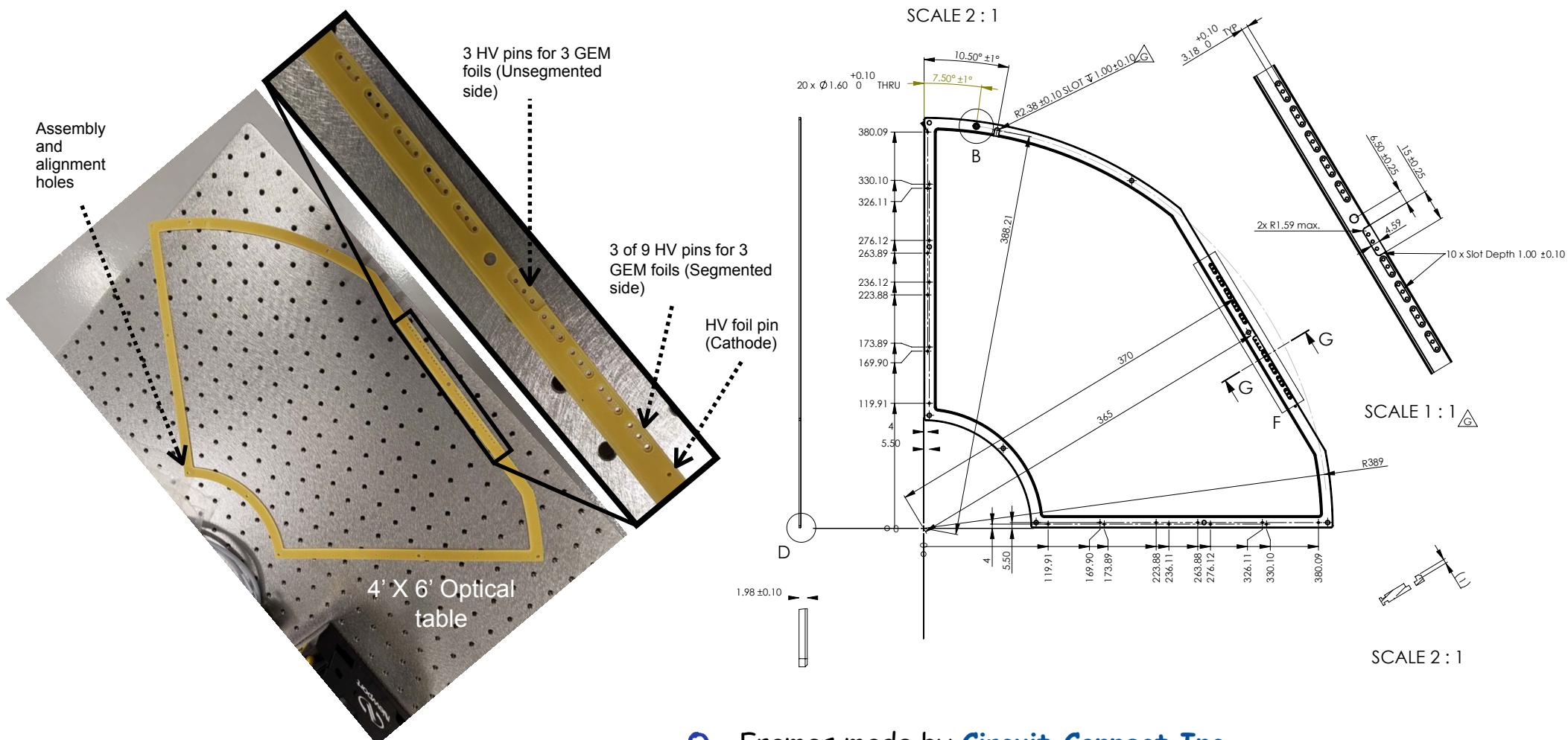
### ○ 5th International Conference on Micro-Pattern Detectors (MPGD2017) at Temple University: Strong recognition of EIC R&D program

- Date: May 22-26, 2017
- Clear recognition of US MPGD R&D program



# Status - Forward GEM Tracking / Generic R&D

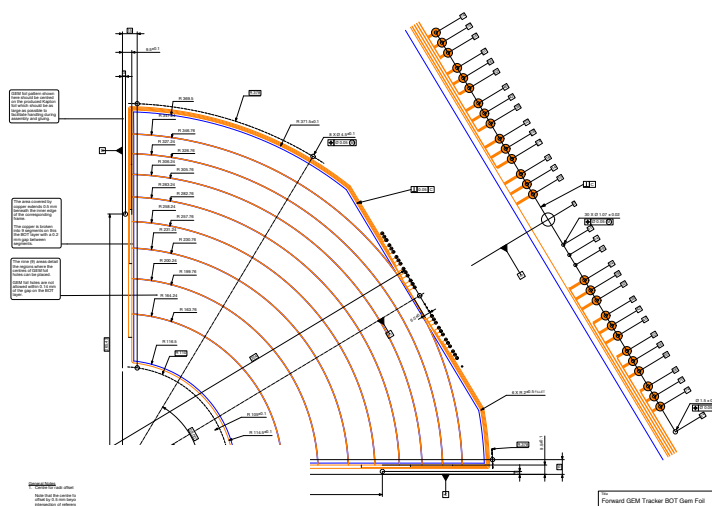
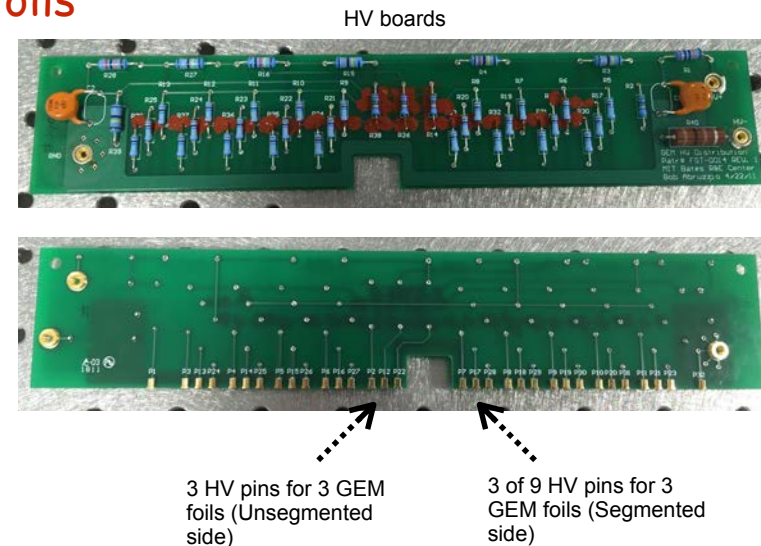
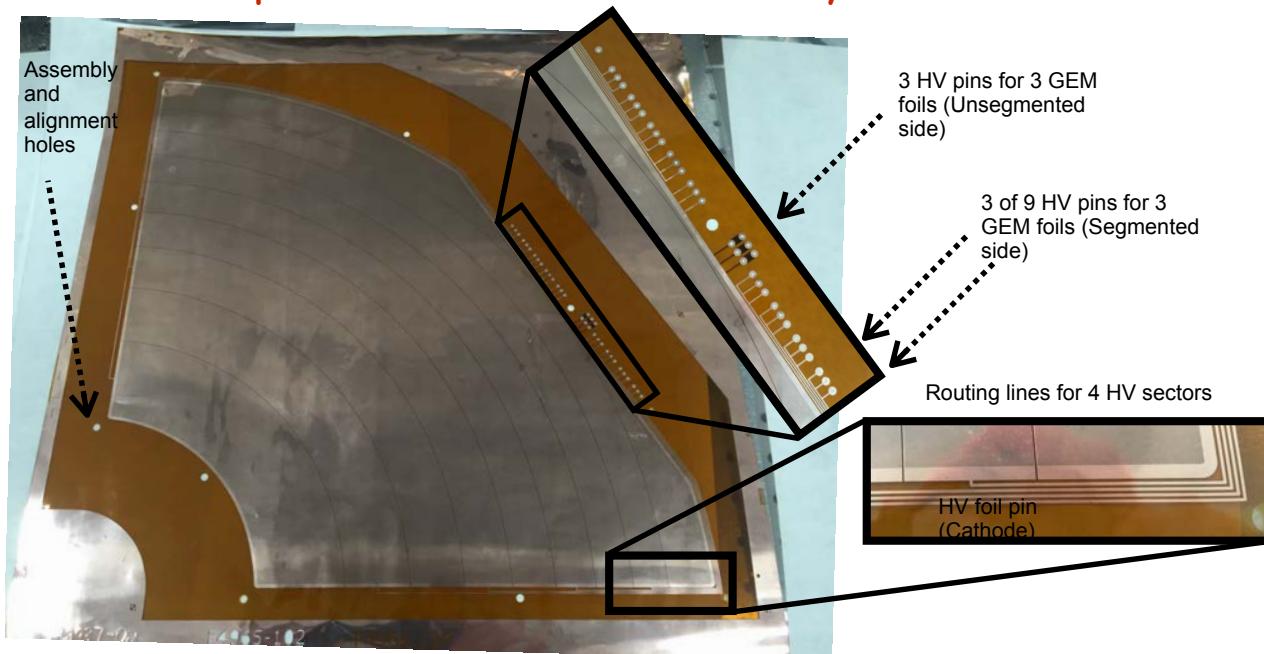
## Triple-GEM detector assembly 40cm X 40cm: Frames



Frames made by **Circuit Connect Inc.**

# Status - Forward GEM Tracking / Generic R&D

## Triple-GEM detector assembly 40cm X 40cm: GEM foils



- Tech-Etch produced single-mask GEM foils
- All Tech-Etch foils tested with  $< 1 \text{ nA}$  up to 550 V